DESCRIPTION

PACKET COMMUNICATION APPARATUS AND PACKET COMMUNICATION
METHOD

Technical Field

The present invention relates to a packet communication apparatus and a packet communication method. More specifically, the present invention relates to a packet communication apparatus and a packet communication method communicating packets through radio channels at high speed.

Background Art

Recently, there has been an increase of examination of high speed packet communication technology called HSDPA (High Speed Downlink Packet Access). HSDPA is a technology of communicating packets on downlink radio channels from base station apparatus to mobile station apparatus at high speed, and its standardization is being promoted by 3GPP (3rd Generation Partnership Project). According to the standardization by 3GPP, HSDPA applies such methods as adaptive modulation scheme or HARQ (Hybrid Automatic Repeat reQuest) to wireless interface to improve the speed on downlink radio channels from base station apparatus to mobile station apparatus. In addition, in HSDPA, a mobile station apparatus reports

channel quality on downlink radio channels to a base station apparatus, and the base station apparatus schedules the order of data transmission to a plurality of mobile station apparatuses and transmits the data.

5   FIG.1 shows a protocol configuration on a user plane when HSDPA is applied.   The figure shows protocols implemented in a mobile station apparatus, a base station apparatus and a control station apparatus controlling the base station apparatus.

10   Of the protocols shown in FIG.1, "RLC" (Radio Link Control) is a retransmission control protocol of the selective repeat request type described in 3GPP TS25.322 "Radio Link Control (RLC) protocol specification" V5.1.0, and is implemented by the mobile station apparatus and

15   the control station apparatus.   "MAC-hs" (Medium Access Control used for high speed)   is a protocol that performs processing related to the HARQ scheme, scheduling and so forth and is implemented by the mobile station apparatus and the base station apparatus.   In addition, "HS-DSCH

20   FP" (High Speed-Downlink Shared Channel Frame Protocol) is a protocol that performs flow control between the MAC-hs of the base stations apparatus and the RLC of the mobile station apparatus and is implemented by the base station apparatus and the control station apparatus.

25   Hereinafter, packet communication between the RLCs between the control station apparatus and the mobile station apparatus will be explained with reference to

the sequence diagram of FIG.2.

For downlink communication from the control station apparatus to the mobile station apparatus, the RLC of the control station apparatus transmits data packets called "AMD-PDUs" (Acknowledge Mode Data-Protocol Data Units) assigned serial sequence numbers to the RLC of the mobile station apparatus through the base station apparatus. At this time, the AMD-PDUs are stored temporally in a MAC-hs buffer in the base station apparatus. FIG.2 shows that AMD-PDU#0-AMD-PDU#127 are stored in order in the buffer of the base station apparatus at time T_1. The number of the AMD-PDUs stored then is determined according to WSN (Window Size Number) which indicates the transmission window size. In FIG.2, WSN is 128 and AMD-PDU#0-AMD-PDU#127 are stored in the buffer of the base station apparatus.

Further, the MAC-hs of the base station apparatus transmits the AMD-PDUs stored in the buffer in order from AMD-PDU#0 according to the downlink data transmission rate from the base station apparatus to the mobile station apparatus.

Meanwhile, for uplink communication from the mobile station apparatus to the control station apparatus, the RLC of the mobile station apparatus transmits a reception status report packet called a "status PDU" through the base station apparatus to the control station apparatus. The status PDU includes reception acknowledgement

information indicating whether or not the AMD-PDUs are received by the RLC of the mobile station apparatus. Therefore, as shown in FIG.2, when the mobile station apparatus does not receive AMD-PDU#0 transmitted from

5   the base station apparatus, at time T_2, status PDU#1 is transmitted through the base station apparatus to the control station apparatus indicating that AMD-PDU#0 has not been received.

The RLC of the control station apparatus receiving

10   status PDU#1 retransmits AMD-PDU#0. The retransmitted AMD-PDU#0 is stored again in the buffer of the base station apparatus at time T_3.

However, in the above-described conventional packet communication, the problem is that a retransmitted packet

15   is stored in the buffer of the base station apparatus and takes time to reach the mobile station apparatus, and the mobile station apparatus repeats requesting retransmission of the retransmitted packet already stored in the buffer. In other words, because the

20   above-mentioned retransmitted AMD-PDU#0 is transmitted after AMD-PDU#127 stored in the buffer is transmitted, the mobile station apparatus requests further retransmission of AMD-PDU#0 with a status PDU, which is transmitted every predetermined timing, before receiving

25   the transmitted AMD-PDU#0.

More specifically, in FIG.2, after status PDU#1 is transmitted at time T_2, the mobile station apparatus

transmits status PDU#2 at a predetermined timing (time T_4). However, status PDU#0 has not been received at time T_4, and so status PDU#2 indicating that AMD-PDU#0 has not been received, is transmitted through the base station

5   apparatus to the control station apparatus.

In addition, the control station apparatus retransmits AMD-PDU#0 again in response to status PDU#2 at time T_5. However, AMD-PDU#0 is not received at time T_6 when next status PDU#3 is to be transmitted to the control

10   station apparatus, and status PDU#3 indicating AMD-PDU#0 has not been received is transmitted through the base station apparatus to the control station apparatus.

Thus, a status PDU indicating that the same AMD-PDU#0 has not been received is transmitted several times, and,

15   when the status PDU is transmitted a predetermined number of times (three times in FIG.2), the control station apparatus transmits, at time T_7, a reset PDU to reset the connection with the control station apparatus.

As a result, TCP (Transmission Control Protocol),

20   an upper RLC layer, performs the transmission of AMD-PDU#0. However, retransmission by the TCP, when a retransmission occurs, the TCP at the transmitting end performs flow control and drastically reduces the amount of transmission data per unit time. This may suppress the

25   more than necessary and the throughput of the overall system may decrease.

In addition, as shown in FIG.2, transmitting the

reset PDU transmitted at time T_7 to the mobile station apparatus requires the time all the AMD-PDUs stored in the buffer are transmitted, and, when a certain time passes after the reset PDU is transmitted, the reset PDU is

5   retransmitted at time T_8, since no response is received from the mobile station apparatus. In addition, if the reset PDU keeps being retransmitted, the control station apparatus and the mobile station apparatus may be disconnected.

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Disclosure of Invention

    It is therefore an object of the present invention to suppress decrease in overall system throughput and prevent communication from being reset or disconnected.

15   An essence of the present invention is to measure channel quality using a received signal, set the transmission window size (WSN) in a status PDU according to the measured channel quality and report the window size number to the signal transmission source.

20   In accordance with one aspect of the present invention, a packet communication apparatus adopts a configuration having: a monitoring section that monitors a channel condition of a radio channel; a determination section that determines a transmission window size of a packet

25   transmission source according to the channel condition monitored; and a transmission section that transmits the determined transmission window size to the packet

transmission source.

In accordance with another aspect of the present invention, a packet communication method is provided having the steps of: monitoring a channel condition of a radio channel; determining a transmission window size of a packet transmission source according to the channel condition monitored; and transmitting the determined transmission window size to the packet transmission source.

Brief Description of Drawings

FIG.1 illustrates a protocol configuration of user plane in HSDPA;

FIG.2 is a sequence diagram showing an example of AMD-PDU communication operation between RLCs;

FIG.3 is a bloc diagram showing a configuration of a mobile station apparatus according to an embodiment of the present invention;

FIG.4A illustrates an example of status PDU transmission timing according to an embodiment;

FIG.4B illustrates another example of status PDU transmission timing according to an embodiment;

FIG.5 is a flow chart showing WSN determining operation according to an embodiment;

FIG.6 illustrates an example of a table for determining WSN according to an embodiment; and

FIG.7 is a sequence drawing showing AMD-PDU

retransmission operation according to an embodiment.

Best Mode for Carrying Out the Invention

With reference now to the accompanying drawings,
5   embodiments of the present invention will be explained
in detail below.

FIG.3 is a bloc diagram showing a configuration of
a mobile station apparatus according to an embodiment
of the present invention. The mobile station apparatus
10   shown in FIG.3 has: antenna 100, radio reception section
110, RLC (Radio Link Control) processing section 120,
ACK generation section 130, channel quality measurement
section   140,   CQI   (Channel   Quality   Indicator)
determination section 150, WSN (Window Size Number)
15   determination section 160, status PDU (Protocol Data
Unit) generation section 170, RLC transmission section
180 and radio transmission section 190. Note that the
mobile station apparatus shown in FIG.3 receives AMD-PDUs
(Acknowledge Mode Data-PDUs) from a control station
20   apparatus through a base station apparatus and that radio
communication is performed between the mobile station
apparatus and the base station apparatus.

Antenna 100 receives an AMD-PDU, which is a data
packet, and transmits a status PDU, which is a reception
25   status report packet, and the AMD-PDU.

Radio reception section 110 receives the AMD-PDU
through antenna 100 and performs predetermined radio

reception processing (such as down conversion and A/D conversion).

RLC processing section 120 refers to the poll field in the AMD-PDU, and, if the poll field indicates a transmission request for a status PDU, orders status PDU generation section 170 to generate a status PDU. Note that the poll field is set by the control station apparatus and the control station apparatus uses the poll field and issues a transmission request for a status PDU with an AMD-PDU, for example, every time a predetermined period passes. More specifically, as shown in FIG.4A for example, the control station apparatus, when not requesting a transmission of a status PDU, sets 0 in the poll field. On the other hand, when requesting a transmission of a status PDU, the control station apparatus sets 1 in the poll field. This causes the mobile station apparatus to transmit a status PDU to the control station apparatus.

In addition, RLC processing section 120 detects the sequence number of the received AMD-PDU, and, as shown in FIG.4B, when the sequence number is discontinuous (for example, when AMD-PDU#1 is received when AMD-PDU#0 has not been received)--in other words, when there is a missing AMD-PDU--RLC processing section 120 orders status PDU generation section 170 to generate a status PDU informing the control station apparatus of the missing AMD-PDU.

ACK generation section 130 generates an ACK/NACK indicating whether or not data transmitted via radio

channels has been demodulated correctly. An ACK/NACK acknowledges the reception of data transmitted from the base station apparatus, which is the direct communicating party station, and is generated in accordance with error

5   detection results, for example, when retransmission in HARQ scheme is performed. ACK generation section 130 generates an ACK when data transmitted via radio channel has been demodulated correctly and on the other hand generates a NACK when there are many errors on the radio

10 channels and data has not been demodulated correctly. And ACK generation section 130 transmits the generated ACK/NACK to the base station apparatus through radio transmission section 190 and antenna 100.

Channel quality measurement section 140 measures

15 the channel quality of the radio channel from the received AMD-PDU. More specifically, channel quality measurement section 140 measures channel quality such as the SIR (Signal to Interference Ratio) or the reception power and so forth.

20   ACK generation section 130 and channel quality measurement section 140 serve as a monitoring section that monitors channel conditions of the radio channel between the base station apparatus and the mobile station apparatus.

25   CQI determination section150 determines the CQI for reporting channel quality to the base station apparatus, which is the direct communicating party station. The CQI

is a reference value indicating channel quality of the
channel from the base station apparatus toward the mobile
station apparatus, and the base station apparatus
performs adaptive modulation which selects a modulation
5   scheme suitable for the cannel condition based on the
CQI reported. Note that the base station apparatus
performs adaptive modulation and the data transmission
rate on the channel from the base station apparatus to
the mobile station apparatus varies according to the
10 channel condition. Therefore, the speed AMD-PDUs are
transmitted from the buffer of the base station apparatus,
which stores the AMD-PDUs temporarily, varies.

WSN determination section 160 determines the WSN
appropriate for the channel condition in accordance with
15 ACK/NACK generation situation and the channel quality
measured, and outputs the WSN to PDU generation section
170. More specifically, WSN determination section160
determines the WSN, for example, according to the ratio
of ACK/NACK generated in ACK generation section 130 in
20 the near past and SIR measurement value.   WSN
determination section160 selects the WSN corresponding
to the ratio of ANK/NACK and SIR measurement value from
a table, for example, and thus determines the WSN.

The WSN determined then may be the number of AMD-PDUs
25 that can be transmitted from the buffer of the base station
apparatus to the mobile station apparatus in the period
the above-mentioned poll field provides 1 (period in which

a status PDU is transmitted from the mobile station apparatus). In other words, when a retransmission of an AMD-PDU is requested with one status PDU, the retransmitted AMD-PDU will not continue being stored in the buffer of the base station apparatus but will have been retransmitted by the time the next status PDU is transmitted. Therefore, a retransmission request for the same AMD-PDU will not be repeated a number of times. Note that the number of AMD-PDUs that can be transmitted from the buffer of the base station apparatus to the mobile station apparatus in a given time varies according to channel conditions of the radio channel. When the channel condition is good, relatively many AMD-PDUs can be transmitted. On the other hand, when the channel condition is poor, only a small number of AMD-PDUs can be transmitted.

In addition, as mentioned above, an ACK is generated when received data has few errors and is demodulated correctly, and so when the ratio an ACK is generated is high, this may be an indication of good channel condition. On the other hand, a NACK is generated when received data has many errors and is not demodulated correctly, and so when the ratio a NACK is generated is high, this may be an indication of poor channel condition. In addition, the SIR and received power of the AMD-PDU represent the magnitude of interference and become an indicator of channel condition.

When ordered to generate a status PDU from RLC processing section 120, status PDU generation section 170 generates a status PDU in a predetermined format. Status PDU generation section 170 generates a status PDU

5   including a request for retransmission of the missing AMD-PDU.

In addition, when "1" is set in the poll field of the received AMD-PDU, status PDU generation section 170 generates a status PDU including a request for

10   retransmission of the AMD-PDU which has been requested retransmission earlier yet has not been retransmitted. That is, status PDU generation section 170 generates a status PDU including a request for retransmission of all AMD-PDUs yet to be received. In addition, when ordered

15   by WSN determination section 160, status PDU generation section 170 sets the WSN determined by WSN determination section160 in the WSN field and generates a status PDU. When the status PDU reaches the control station apparatus, the control station apparatus refers to the WSN field

20   and sets the transmission window. Therefore, when the WSN determined by WSN determination section160 is big, the control station apparatus makes the transmission window larger, and, when the WSN determined by WSN determination section160 is small, the control station

25   apparatus makes the transmission window smaller.

RLC transmission section 180 applies RLC processing to the status PDU and transmission data and outputs the

result to radio transmission section 190.

Radio transmission section 190 performs predetermined radio transmission processing (D/A conversion, up-conversion, and so forth) with the status
5   PDU and the PDU of the transmission data and outputs the result through antenna 100.

Next, the WSN determination operation of the mobile station apparatus of the above-described configuration will be explained with reference to the flow chart shown
10   in FIG.5.

First, radio reception section 110 receives an AMD-PDU through antenna 100 and channel quality measurement section 140 measures channel quality such as the SIR (ST1000), and information about the measured
15   channel quality is output to WSN determination section160. An ACK/NACK is generated by ACK generation section 130 in response to data transmitted from the base station apparatus and retransmission control in HARQ scheme is performed, and the generated ACK/NACK is output to WSN
20   determination section160.

Further, WSN determination section160 calculates the ratio of ACK/NACK generated in the near past and the situation of retransmission request is determined (ST1100). In other words, WSN determination section160
25   stores, for example, a generation history of predetermined number of ACK/NACK and the ratio of ACK (or NACK) account for the generation history is calculated.

At this time, that the ratio of ACK is high means that there are few errors in a radio channel of a reception data; therefore, a channel condition is regarded as in good order.

5   When the retransmission situation is determined, WSN determination section160 refers to, for example, a table as shown in FIG.6 and decides a transmission window size number (that is, WSN) according to a current channel condition (ST1200). FIG.6 is an example of a table for

10   determining the WSN from a generation history of. five ACK/NACKs and channel quality measured by channel quality measurement section 140. As shown in the figure, when the generation history of five ACK/NACK shows all ACKs and also channel quality is greater than the predetermined

15   threshold value b, the channel condition is determined to be optimal and the WSN is determined to be the maximum of 150. On the other hand, when the generation history of ACK/NACKs shows all NACKs and also the channel quality is below the predetermined threshold value a, the channel

20   condition is judged to be very poor and the WSN is determined 4 to be the minimum of 4.

The reason the WSN is determined this way is as follows: That is, when the channel condition is good, the transmission rate from the base station apparatus

25   to the mobile station apparatus increases and the speed AMD-PDUs are transmitted from the buffer of the base station apparatus becomes faster, and consequently, a

lot of AMD-PDU is not stored in a buffer of the base station

apparatus although a window size number of the control

station apparatus is big. On the other hand, when the

channel condition is poor, the data transmission rate

5 from the base station apparatus to the control station

apparatus decreases, and AMD-PDUs stay longer in the

buffer of the base station apparatus. Therefore, the

transmission window size needs to be made smaller when

the channel condition is poor.

10   Further, a decision is made whether or not the

determined WSN is different from the one previously

determined (ST 1300). When the WSN is different from the

previously determined one, the newly determined WSN is

reported to stats PDU generation section 170 to be set

15 in a status PDU. Status PDU generation section 170

generates a status PDU by an indication of RLC processing

section 120, the WSN determined by WSN determination

section160 is set in the WSN field of the status PDU

(ST1400).

20   Thus status PDU generated thus is subjected to RLC

processing by RLC transmission section 180, subjected

to predetermined radio transmission processing by radio

transmission section 190, and transmitted through antenna

100. The status PDU is then transmitted to the control

25 station apparatus though the base station apparatus.

The control station apparatus changes the

transmission window size referring to the WSN field of

the received status PDU and retransmits the AMD-PDU
requested to be retransmitted by the status PDU. By this
means, when the channel condition of the radio channel
between the mobile station apparatus and the base station

5   apparatus is good, relatively many AMD-PDUs are
transmitted from the control station apparatus to the
base station apparatus, while, when the channel condition
of the radio channel between the mobile station apparatus
and the base station apparatus is poor, relatively few

10 AMD-PDUs are transmitted from the control station
apparatus to the base station apparatus. Therefore, even
if the data transmission rate from the base station
apparatus to the mobile station apparatus varies by
adaptive modulation, AMD-PDUs are stored in the buffer

15 of the base station apparatus regularly in an amount in
accordance with the channel condition of the radio channel
between the mobile station apparatus and the base station
apparatus, so that an AMD-PDU retransmitted in response
to a retransmission request by a status PDU will not stay

20 stored in the buffer of the base station apparatus for
a long time.

Hereinafter,   the   situation   of   AMD-PDU
retransmission will be explained with reference to the
sequence diagram of FIG.7. FIG.7 describes the operation

25 of the mobile station apparatus transmitting status PDU#0
to report the WSN.

First, at time T_0, status PDU#0 generated by status

PDU generation 170 of the mobile station apparatus is transmitted through the base station apparatus to the control station apparatus. The WSN determined by WSN determination section160 in accordance with the channel

5   condition of the radio channel is set in the WSN field of status PDU#0, the value being 4. This WSN is, as mentioned above, determined according to the channel condition of the radio channel between the mobile station apparatus and the base station apparatus.

10   Upon reception of the status PDU#0, the control station apparatus makes the transmission window size 4 referring to the WSN field. In other words, the control station apparatus transmits four AMD-PDUs (AMD-PDU#0-3) simultaneously. These AMD-PDU#0-3 are received by the

15   base station apparatus at time T1 and stored temporally in MAC-hs buffer of the base station apparatus.

        The base station apparatus transmits AMD-PDU#0-3 stored in the buffer one by one to the mobile station apparatus. At this time, if AMD-PDU#0 is lost on the radio

20   channel, AMD-PDU#1 will be the first to be received by the mobile station apparatus.

        RLC processing section 120 of the mobile station apparatus detects that the sequence number is discontinuous (that is, when it is detected that AMD-PDU#1

25   is received without receiving AMD-PDU#0), and status PDU generation section 170 generates status PDU#1 to request retransmission of AMD-PDU#0. If the channel condition

of the radio channel has changed by then and a new WSN

has been determined, the new WSN is set in status PDU#1,

and if the new WSN is the same as the previous WSN, the

WSN field of statusPDU#1 is not used.

5   Status PDU#1 generated by status generation section

170 is, at time T_2, transmitted from antenna 100, through

the base station apparatus, to the control station

apparatus.

The control station apparatus retransmits AMD-PDU#0

10 requested for retransmission upon reception of

statusPDU#1.   AMD-PDU#0   that   is   retransmitted

(hereinafter referred to as "AMD-PDU#0 (retransmitted)")

to avoid confusion) is received by the base station

apparatus and stored in the buffer at time T_3. At this

15 time, in the buffer of the base station apparatus, only

two ADM-PDUs, namely ADM-PDU#2 and ADM-PDU#3, are stored

at a maximum and it takes relatively a short time to

transmit AMD-PDU#0 (retransmitted) from the base station

apparatus to the mobile station apparatus. This is

20 because the transmission window size of the control

station size is set 4 by status PDU#0 and the number of

AMD-PDUs simultaneously transmitted from the control

station apparatus is suppressed.

Further, the base station apparatus transmits

25 AMD-PDU#0 (retransmitted) at time T_4 after transmitting

AMD-PDU#2 and AMD-PDU#3 stored in the buffer. If

arrangement is made such that an AMD-PDU having 1 set

in the poll field (in other words, one that requests transmission of a status PDU) is not transmitted until AMD-PDU#0 (retransmitted) is received by the base station apparatus, one retransmission request AMD-PDU#0 will

5   suffice.

Thus, according to the present embodiment, the mobile station apparatus determines the WSN, which is the transmission window, according to the channel condition of the radio channel and reports the WSN to

10 the control station apparatus, which is the AMD-PDU transmission source, so that an AMD-PDU that is retransmitted from the control station apparatus will not be stored long in the buffer of the base station apparatus relaying between the mobile station apparatus

15 and the control station apparatus. Therefore, it is possible to prevent issuing too many retransmission requests for the same AMD-PDU, suppress decrease in overall system throughput, and prevent communication from being reset or disconnected. In addition, according to

20 the present embodiment, changes in the configuration of the mobile station apparatus make it possible to determine the optimal WSN size, and there is no need to make changes to existing radio communication systems as the base station apparatus and the control station apparatus.

25 As explained above, with the present invention, it is possible to suppress decrease in overall system and prevent communication from being reset or disconnected.

This application is based on Japanese Patent Application No.2003-278885 field on July 24, 2003, the entire content of which is expressly incorporated by reference herein.

Industrial Applicability

The present invention makes it possible to suppress decrease in overall system throughput and prevent communication from being reset or disconnected, and the present invention is particularly suitable for a packet communication apparatus and a packet communication method which communicates packets at high speed through radio channels.